	L #	Hits	Search Text	DBs	Time Stamp
1	L1	9760	Delphi.as.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:00
2	L2	73	1 and ((bond near pad) or (bonding near pad))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 08:44
3	L3	70	2 and ((@ad<"20031015") or (@rlad<"20031015"))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:55

	L #	Hits	Search Text	DBs	Time Stamp
4	L4	4	3 and diode	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 08:47
5	L5	4	("4054875" | "5837562" | "6049313" | "6282352").PN.	US-PGPUB; USPAT; USOCR	2005/06/09 08:48
6	L6	7	("2894124" | "3553610" | "3668551" | "3696314" | "3924208").PN.	US-PGPUB; USPAT; USOCR	2005/06/09 08:52
7	L7	5	("4054875").URPN.	USPAT	2005/06/09 08:52
8	L8	2	("6555856").URPN.	USPAT	2005/06/09 08:53
9	L9	233	1 and diode	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:00

	L #	Hits	Search Text	DBs	Time Stamp
10	L10	10	9 and moisture	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:17
11	L11	92554	hermetically near4 seal$6	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:03
12	L12	4942	11 and MEM	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:03

	L #	Hits	Search Text	DBs	Time Stamp
13	L13	25	12 and diaphram	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:05
14	L14	1260001	cap or capping or lid	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:05
15	L15	11547	14 same wafer	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:06

	L #	Hits	Search Text	DBs	Time Stamp
16	L16	1451	15 and diode	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:06
17	L17	145	16 and moisture	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:06
18	L18	54	17 and port	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:15

	L #	Hits	Search Text	DBs	Time Stamp
19	L19	1	(cap or capping) with bond$6 with (cavity or opening) with port with diode	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:16
20	L20	1445	(cap or capping) and bond$6 and (cavity or opening) and port and diode	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:16
21	L21	319	20 and moisture	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:17

	L #	Hits	Search Text	DBs	Time Stamp
22	L22	307	21 and ((@ad<"20031015") or (@rlad<"20031015"))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:20
23	L23	91	22 and wafer	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:23
24	L24	11857	motion near sensor	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:23

	L #	Hits	Search Text	DBs	Time Stamp
25	L25	1305	24 and cavity	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:23
26	L26	458	25 and port	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:23
27	L27	87	26 and moisture	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:24

	L #	Hits	Search Text	DBs	Time Stamp
28	L28	108788	(hermetic or hermetically) near4 (seal or sealed or sealing)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:25
29	L29	7053	28 and diode	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:25
30	L30	1505	29 and port	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:25

	L #	Hits	Search Text	DBs	Time Stamp
31	L31	500	30 and pad	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:25
32	L32	143	31 and (cap or capping)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:29
33	L33	1353	christenson.in.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:30

	L #	Hits	Search Text	DBs	Time Stamp
34	L35	6	34 and diode	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:30
35	L34	151	33 and port	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:31
36	L37	29	34 and john	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:47

	L #	Hits	Search Text	DBs	Time Stamp
37	L38	254	(324/152).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:47
38	L39	14	38 and port	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:47
39	L40	4206	Rich.in.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:48

	L #	Hits	Search Text	DBs	Time Stamp
40	L41	390	40 and port	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:48
41	L42	14	41 and diode	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 09:48
42	L43	0	("2005/0093533").URPN.	USPAT	2005/06/09 09:49
43	L44	2	("5721162").PN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:05

	L #	Hits	Search Text	DBs	Time Stamp
44	L45	3337	PN near junction near diode	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:06
45	L46	66	45 and moisture	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:06
46	L47	62	46 and ((@ad<"20031015") or (@rlad<"20031015"))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:20

	L #	Hits	Search Text	DBs	Time Stamp
47	L48	5173	(detect or detection or detecting) near4 moisture	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:21
48	L49	644	48 and diode	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:21
49	L50	155	49 and port	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:21

	L #	Hits	Search Text	DBs	Time Stamp
50	L51	148	50 and ((@ad<"20031015") or (@rlad<"20031015"))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:23
51	L52	14664	retain$6 near4 moisture	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:25
52	L53	360	52 and MEM	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:26

	L #	Hits	Search Text	DBs	Time Stamp
53	L54	10	53 and hermetically	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:25
54	L55	2	53 and diode	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:26
55	L56	101	53 and port	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:27

	L #	Hits	Search Text	DBs	Time Stamp
56	L57	121941	(detect$6 or check$6 or test or testing or tested) near4 (moist or moisture or wet or wetness or damp or dampness or liquid)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:29
57	L58	6905	57 and diode	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:29
58	L59	1879	58 and (seal or sealing or sealing or sealant)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:30

	L #	Hits	Search Text	DBs	Time Stamp
59	L60	805	59 and port	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:30
60	L61	659	60 and (cavity or opening or recess or recesses)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:30
61	L62	625	61 and ((@ad<"20031015") or (@rlad<"20031015"))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:30

	L #	Hits	Search Text	DBs	Time Stamp
62	L63	284	62 and (wafer or substrate)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:32
63	L64	237	63 and (container or tank or reservoir)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:32
64	L65	234	64 and (reduce or hold or reducing or holding or maintain or maintaining or preserve)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:40

	L #	Hits	Search Text	DBs	Time Stamp
65	L66	16	65 and MEM	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:44
66	L67	437809	(microelectro near mechanical) or MEM or (micro-electro adj mechnical)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:44
67	L68	441764	(microelectro near mechanical) or MEM or (micro-electro adj mechnical) or (micromachine) or micro-machine	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:45

	L #	Hits	Search Text	DBs	Time Stamp
68	L69	50	1 and 68	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:46
69	L70	17	69 and (moisture or moist or wet or wetness or damp or dampness)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:52
70	L71	25246	(leak or leaking or leaked) near4 (detect or detecting or detector or detection)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:52

	L #	Hits	Search Text	DBs	Time Stamp
71	L72	27	1 and 71	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:54
72	L73	8944	71 and (sensor or sensing)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:54
73	L74	164	73 and 68	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:55

	L #	Hits	Search Text	DBs	Time Stamp
74	L75	141	74 and ((@ad<"20031015") or (@rlad<"20031015"))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2005/06/09 10:55

US-PAT-NO: 6555856

DOCUMENT-IDENTIFIER: US 6555856 B1

TITLE: Semiconductor device with means for verifying a hermetic seal therefor

---------- KWIC ---------

Abstract Text - ABTX (1):

A method and device for verifying whether a cavity (16) enclosing a micromachined sensing structure (14) between a pair of wafers (10, 12) is hermetically sealed by detecting the presence of **moisture** within the cavity (16). The method entails forming a bare, unpassivated PN junction diode (20) in a semiconductor substrate, preferably a device wafer (10) with the sensing structure (14). The device wafer (10) is then bonded to a capping wafer (12) to enclose the PN junction diode (20) and **micromachine** (14) within a cavity (16) defined by and between the wafers (10, 12). The reverse diode characteristics of the PN junction diode (20) are then determined by causing a reverse current to flow through the diode (20). For this purpose, either a known voltage is applied across the diode (20) and the reverse leakage current measured, or a known reverse current is forced across the diode (20) and the voltage measured. The unpassivated junction diode (20) exhibits unstable current/voltage readings if sufficient **moisture** is present within the cavity (16), thereby indicating whether or not the cavity (16) is hermetically sealed.

Assignee Name - ASNM (1):

Delphi Technologies, Inc.

Brief Summary Text - BSTX (2):

The present invention generally relates to methods for verifying whether a cavity is hermetically sealed, such as when semiconductor wafers are

bonded
together to hermetically enclose a micromachined sensing structure. More
particularly, this invention relates to an electrical verification technique
and device for detecting **moisture** within a cavity enclosing a **micromachine**
sensing structure as an indication of whether the sensing structure is
hermetically sealed within the cavity.

Brief Summary Text - BSTX (4):

Within the semiconductor industry, there are numerous applications that
require bonding a semiconductor wafer to a second wafer or glass, an example
being sensors formed by a silicon wafer (referred to herein as a device wafer)
with a micromachined sensing structure (**micromachine**), which is capped by a
semiconductor or glass wafer (referred to herein as a capping wafer). Examples
of semiconductor sensors include yaw (angular rate) sensors, accelerometers and
pressure sensors, each of which typically entails a cavity that encloses the
micromachine between the wafers. Absolute pressure sensors require that the
cavity be evacuated and hermetically sealed, while the performance of yaw
sensors with resonating **micromachines** generally benefit if the cavity is
evacuated so that the **micromachine** operates in a vacuum.

Brief Summary Text - BSTX (5):

By the very nature of their operation, **micromachines** must be free to move to
some degree, necessitating that the seal between the wafers is sufficient to
exclude foreign matter from the cavity. A hermetical seal ensures that
moisture is also excluded, which would form ice crystals at low temperatures
that could impede motion of the **micromachine**. Accordingly, the integrity of
the bond between the wafers is essential to the life of a semiconductor sensor.
Various bonding techniques have been used for the purpose of maximizing the
strength and reliability of the bond. For example, the use of

adhesives,
dielectrics such as glass frit, and solders as intermediate bonding materials
has been suggested in the prior art. Silicon direct and anodic bonding
techniques that do not require an intermediate material have also been used.
As would be expected, the conditions vary under which each of these bonding
techniques will reliably yield a hermetic seal.

Brief Summary Text - BSTX (9):
It is another object of this invention that such a method employs a PN
junction diode to sense the presence of **moisture** within the cavity as an
indication of whether the seal is hermetic or not.

Brief Summary Text - BSTX (11):
It is still another object of this invention that such a method is useful to
inspect semiconductor sensors with **micromachine** sensing structures.

Brief Summary Text - BSTX (13):
According to the present invention, there is provided a method and device
for verifying whether a cavity enclosing a micromachined sensing structure
between a pair of wafers is hermetically sealed. The invention entails an
electrical verification technique and semiconductor device that detects
moisture within the cavity as an indication of whether the sensing structure is
hermetically sealed within the cavity.

Brief Summary Text - BSTX (14):
The method of this invention generally entails forming a bare, unpassivated
PN junction diode in a semiconductor substrate, preferably a device wafer
having a **micromachine** sensing structure. For example, the PN junction diode
can be formed by implanting a P-type region in an N-type epitaxial layer of the
device wafer. The device wafer is then bonded to a capping wafer of any
suitable material to enclose the PN junction diode and **micromachine** within a
cavity defined by and between the wafers. Bonding can be achieved by

From the above, it was concluded that the bare PN junction diodes evaluated were insensitive to relative humidities of less than 10%, but would detect leaks in a bonded wafer assembly exposed to humidity levels typically seen during processing, e.g., that used to generate the data of Tables I and II, and generally relative humidities of 85% and higher. Further testing has indicated that the unpassivated PN junction diodes 20 of this invention are affected by **moisture** at humidity levels as low as about 40% RH, though it is foreseeable that the sensitivity of a bare PN junction diode may be greater or less under different conditions.

Claims Text - CLTX (1):
1. A semiconductor sensor comprising: a semiconductor wafer bonded to a capping wafer so as to define a cavity therebetween; an unpassivated PN junction diode in a first surface region of the semiconductor wafer and enclosed within the cavity; a **micromachine** sensing structure in a second surface region of the semiconductor wafer and enclosed within the cavity; and a reverse current flowing through the unpassivated PN junction diode, wherein a reverse current or voltage caused by the reverse current is an indication of the presence of **moisture** within the cavity.

Claims Text - CLTX (2):
2. A semiconductor sensor comprising: a device wafer bonded to a capping wafer so as to define a cavity therebetween; a bare PN junction diode in a semiconductor substrate enclosed within the cavity; and means for flowing a reverse current through the bare PN junction diode, wherein the reverse current or voltage caused by the reverse current is an indication of the presence of **moisture** within the cavity.

Claims Text - CLTX (5):
5. A semiconductor sensor according to claim 4, further

comprising a
micromachine on the device wafer.

Claims Text - CLTX (7):
7. A semiconductor sensor according to claim 4, further comprising a reverse current flowing through the bare PN junction diode, wherein a reverse current or voltage caused by the reverse current is an indication of the presence of **moisture** within the cavity.